FOOD CHARACTERIZATION/PROCESS/PRODUCT RESEARCH

Panel Manager - Dr. Jon M. Faubion, American Association of Cereal Chemists
Program Director - Mr. Jeffery L. Conrad

This program area seeks to better understand the properties (physical, chemical and biological) of raw agricultural materials and products related to their quality and processing characteristics and to develop innovative products and processes for better utilization and more efficient conversion of agricultural materials to higher value food products. Specifically, research is supported on value-added food products which contribute to expanded markets for agricultural commodities, lower-cost food products, and a more competitive domestic food industry with expanded export opportunities. This program supports research to increase the quality, utility, convenience, nutrient value, and safety of food products through innovative processing methods. Research providing the basis for development of new food products is also supported

2000-01809 pH Modification in Wine Using Cationic Membranes

Morris, J. R. Main, G. L.
University of Arkansas; Institute of Food Science and Engineering; Fayetteville, AR 72704
Strengthening Award; Grant 2001-35503-10201; $35,740, 1 Year

Grapes grown in warm climates often result in wines with high pH that cannot be corrected by simple acid additions. These wines are often of lessor quality and have a short shelf life. The high pH can be corrected using ion exchange but wine quality is an issue. Existing ion exchange systems are not suitable for use in premium wines for lowering pH because resins remove flavor components and color. Cation selective membranes have the potential for lowering wine pH. Since there is no resin bed to adsorb desirable components and no resin bed to regenerates the process is simpler than resin based systems and should improve wine quality. A 3-chamber electrochemical ion exchange unit using cation membranes to separate the middle cell from adjacent cells will be used in our tests. Wine is passed through the middle cell with an acid and a base in the adjacent cells. As current is passed across the cell, H+ is exchanged for K+ in the wine and K+ moves to the catholyte. Large changes in pH are possible depending on amount of K+ in the wine. In this study, we will compare wine quality for resin-based vs. membrane-based ion exchange. Also, we will determine if cation exchange membranes from different manufacturers have the same effect on wine quality. Should this technology prove economical and feasible it will provide a useful tool for premium wine production.

2000-01614 Removal of Aflatoxin Contaminated Peanuts from a Process Stream

Schatzki, T. F.
Agricultural Research Service, PWA; Western Regional Research Center; Albany, CA 74710-1105
Grant 2001-35503-10192; $217,000; 3 Years

Nuts, corn, rice, some spices and coffee are foods susceptible to mold attack under certain conditions. For these foods, molds exist which may produce a deleterious

toxin, named aflatoxin. Aflatoxin may cause liver trauma, including cancer in rare cases. Moreover, its presence will cause foreign buyers to reject the food. Among nuts, and particularly among peanuts, this toxin is found, if at all, in very few nuts in a lot, maybe 1 in 1000 or 10,000 nuts. On the other hand, the aflatoxin level in these few nuts may be quite high, leading to a high overall average concentration in the lot. The rarity of contamination suggests that sorting methods, i.e., removal of the contaminated nuts from a process stream, may be a very effective method for limiting this toxin. What is needed is a sorter which can, at high speed and high volume, recognize and remove contaminated peanuts. Unfortunately, high contamination levels are not always visible externally. Nevertheless, we are now attempting to develop such a sorter. The first step requires the collection of a reasonable size sample of whole, but contaminated, nuts along with a sample of uncontaminated nuts. The next step is to establish properties, principally transmission of light or similar radiation, which can look inside the nut and which are sensitive to contamination. Next, detectors must be found which can react at adequate speed for sorting. Such detectors are expected to be available from the semiconductor industry. And, finally, a sorter, based on these principles, must be constructed. We are well along in the first step, selecting a set of contaminated nuts without damaging them. The present project is designed to carry out the remaining steps.

2000-01606 Interaction of Flavors with Polyphenols

Ebeler, S.
University of California, Davis; Department of Viticulture and Enology; Davis, CA 95616

Grant 2001-35503-10028; $150,900; 3 Years

Flavor is one of the most important factors influencing consumer food and beverage choices. However, knowledge of the amount of individual flavor compounds present in a food or beverage is not sufficient to understand or predict the perceived flavor intensity of the product. This is due to chemical and physical interactions between the flavor compounds and other food components (e.g., proteins, lipids, and carbohydrates) which alter the release and volatility of the flavorants. Polyphenols are widely distributed in foods (e.g., citrus, cocoa, apples, blueberries, plums, sorghum, etc.) and beverages (e.g., wine, tea, coffee, beer, etc.), however, little is known about the effect they may have on volatile flavor constituents. In addition, many recent studies suggest that dietary phenols may reduce the risk of a number of diseases, including heart disease and cancer. As more is learned of these health effects there will be the potential for optimizing the amounts of polyphenols present in foods and beverages through agricultural practices and processing parameters. The goal of this research it to relate quantitative analytical information with human sensory evaluations in order to provide an improved understanding of how polyphenols influence aroma intensity and flavor perception. By understanding the underlying mechanisms of these interactions and their effects on flavor perception, it will be possible to optimize the composition of food ingredients and food processing conditions in order to provide healthful foods with improved flavor.

2000-01699 Structure-Function Relationships of Plant Proteoglycans as Food Emulsifiers

Nothnagel, E. A.
University of California, Riverside; Department of Botany and Plant Sciences; Riverside, CA 92521-0124
Grant 2001-35503-10027; $180,000; 3 Years

Emulsifiers are used to stabilize dispersions of oil in water in various foods, cosmetics, and other products. Although many emulsifiers exist, gum arabic has been used longest and remains unmatched in certain applications, such as dilute dispersions of citrus oils in soft drinks. Gum arabic is imported from Sudan and neighboring countries of Africa where it is produced by Acacia trees. Because of political problems and environmental fluctuations, the supply of gum arabic has been unreliable. The purpose of this project is to determine the precise molecular structural features that cause gum arabic to be an outstanding emulsifier. Previous studies have not established this point but have shown that gum arabic is a mixture of several types of molecules, of which only 2% are the best emulsifiers. The project hypothesis is that these 2% of the molecules contain, as part of their structure, a lipid group that is key to emulsifying activity. If this hypothesis proves correct, the project will turn toward using this information to develop new emulsifiers. Evidence from this laboratory indicates that many plants growing in the United States probably produce molecules with lipid groups like those hypothesized to be present in gum arabic. These lipid-containing molecules will be extracted from various plant materials and tested for emulsifying activity. Alternatively, lipid groups will be attached to citrus pectin and other plant polysaccharides that are produced in abundance in the United States to determine if this modification converts them into highly effective, low cost emulsifiers.

2000-01639 Enzymatic Production of Structured Lipids: Application in Model Food Emulsions

Akoh, C. C.
University of Georgia, Athens; Department of Food Science and Technology; Athens, GA 30602-7610
Grant 2001-35503-10037; $131,900; 2 Years

The proposed research will use an enzyme bioreactor to produce digestible healthy lipids, otherwise known as structured lipids, by converting vegetable and fish oils to high-value products. Structured lipids are fats and oils containing short and/or medium and long chain fatty acids esterified to the glycerol portion of the fat and oil molecule. Lipases (enzymes) will be used in place of chemical catalysts because lipase reactions are specific and can put specific fatty acids at desired positions on the glycerol. Canola and fish oil-based structured lipids will be produced in kilogram quantities, using caprylic acid as acyl donor, and used to study the formation and stability of model oil-in-water food emulsions in the presence of emulsifiers. The effect of structured lipids and added antioxidants on the kinetics of lipid oxidation in the model emulsion system will be determined. The basic understanding gained from this research will be a good first step toward the application of structured lipids in more complex mainstream food products such as beverages, dressings, soups, infant formula, and meal replacers, as functional foods and nutraceuticals. Use of enzymes is environmentally friendly and may serve as

an alternative to genetic modification of oil crops to provide healthful lipids with potential for export and domestic markets. Structured lipids have the potential to improve our overall health, for use in enteral and parenteral nutrition, reduce cholesterol and cancer risk, and to modify the functional and physical properties of food products.

2000-01801 Impact of Endosperm Lipids on Dry Milling and Extrusion of Dried and Stored Corn

White, P. J.; Seetharaman, K.; Bern, C. J.
Iowa State University; Department of Food Science and Human Nutrition; Ames, IA 50011
Grant 2001-35503-10030; $184,500; 3 Years

Corn is harvested once a year and utilized by the food industry throughout the year. Storage of grain over extended periods of time alters the processability of the grain resulting in significant operating losses for the food industry. While it is well known that changes occur in grain during storage, the nature of changes taking place is unclear and there is no means of predicting changes so as to prevent or minimize operating losses. The long-term goal of this project is to understand the biochemical changes taking place in corn during extended post-harvest storage and the implications of these changes on the quality and processability of grains. The goal of this proposed study is focused specifically on investigating and documenting changes in endosperm lipids in corn, an area that has received scant attention in the research literature. We hypothesize that changes in native endosperm lipids play a significant role in modifying endosperm properties following extended storage. The significance of the proposed study is that the results will lead to improved grain quality and processed products, which will aid producers in adding value to the corn they grow and maintaining the value during storage. It also will aid producers in better assessing, sourcing and processing corn of consistent quality throughout the growing season.

2000-01705 Influence of Protein Oxidation on Mechanisms Governing Meat Tenderness

Lonergan, E.; Huff, J.
Iowa State University; Department of Animal Science; Ames, IA 50011
New Investigator Award; Grant 2001-35503-10024; $112,000; 2 Years

Inconsistent beef tenderness is estimated to cost the beef industry over $216,000,000 annually. This has long been recognized as a significant problem, yet little progress has been made toward consistently producing tender beef. Meat tenderness develops as a result of biochemical processes including proteolysis of key structural proteins. Because the calcium-dependent cysteine proteases, calpains, have been implicated in this process, much tenderness research has focused on interactions between the endogenous calpains, (- and m-calpain) and their inhibitor calpastatin. In addition to other changes in early postmortem muscle (pH decline, rise in ionic strength) the antioxidant defense system becomes compromised. It is probable that subsequent oxidative processes in postmortem muscle affect the rate of tenderization by negatively influencing calpain activity because - and m-calpain are cysteine proteinases and require reducing conditions to be active. Preliminary data have led to the hypothesis that oxidation of postmortem tissue suppresses calpain activity and slows the rate of calpain-

induced meat tenderization. The overall objective of this study is to establish the role of tissue oxidation in regulating postmortem calpain activity and resultant meat tenderness. Specific objectives include (1) quantify the extent to which oxidation under postmortem-like conditions impedes the ability of - and m-calpains to degrade myofibrillar protein substrates in vitro, and (2) to determine the mechanism by which oxidation slows meat tenderization *in situ*. By examining the role of protein oxidation in regulating calpain activity, this project takes a new approach in seeking mechanisms responsible for variation in the rate that meat becomes tender.

2000-01785 Mechanisms and Control of Off-Odor Production in Irradiated Turkey Breast Meat

Ahn, D. U.; Olson, D. G.; Love, J.
Iowa State University; Department of Animal Science; Ames, IA 50011
Grant 2001-35503-10029; $180,500; 3 Years

Irradiation is an effective technology for inactivating foodborne pathogens and improving
the microbial safety of raw meat. A major concern in irradiating meat, however, is the production of a characteristic irradiation aroma and alteration of meat flavor, which could significantly impact upon consumer acceptance. The objectives of this research are to determine the mechanisms of off-odor production in irradiated meat, to screen antioxidants that can reduce lipid oxidation and off-odor production in irradiated meat, and to determine the effect of selected antioxidants on sensory characteristics and consumer acceptance of irradiated turkey breast meat. Mechanisms of off-odor production by irradiation will be studied using model systems of amino acid homopolymers, fatty acids, and liposomes containing amino acid homopolymers. Volatile compounds produced in the irradiated model systems will be identified and quantified using gas chromatography-mass spectrometry and compared with those of irradiated raw meat. Control of off-odor production in irradiated raw turkey meat will be studied with both meat homogenates and ground meat systems. Various antioxidant combinations will be tested for their efficiency in reducing lipid oxidation and off-odor volatiles in meat homogenates. Selected antioxidant combinations will be added in ground turkey breast meat, irradiated, and then tested for sensory characteristics and consumer acceptance. Understanding the mechanisms of lipid oxidation and volatiles formation by irradiation, and finding methods to minimize off-odor production in irradiated meat will be important for the meat industry as it implements irradiation technology.

2000-01212 Understanding Variant Soft Wheat Starch Behavior due to Genotype and Environment

Huber, K.C.
University of Idaho; Department of Food Science and Toxicology; Moscow, ID 83844
Seed Grant; Grant 2001-35501-10198; $75,000; 2 Years

Soft wheat cultivars, especially those exhibiting partial waxy character, have shown genuine promise for utilization in Japanese-style noodles. Nevertheless, the quality and end-use properties of flours grown in the Pacific Northwest have been shown to vary significantly by to cultivar, crop year, and growing location. Since starch is the primary component responsible for the rheological behavior of flour in noodle products,

the observed fluctuations in flour properties have been linked to variability within the starch fraction.

The goal of this work is to identify the compositional and/or structural features within the starch fraction that are responsible for the variable properties observed among flours and starches of both differing and identical genetic background cultivated under diverse environmental conditions. Research focus will be directed to the characterization of the intrinsic characteristics and physical properties of the A- and B-type starch granule populations, whose composition, structure, and distribution within the wheat endosperm could explain the variable quality of flours. Relationships between starch intrinsic characteristics and physical properties will be used to identify components critical to starch behavior. Knowledge of the factors that influence the quality of wheat for specific end-uses is critical for competitiveness in the global marketplace and represents a vital element for the long-term sustainability of US production agriculture. The quality of wheat will be enhanced if important traits responsible for starch properties can be manipulated to improve function and minimize inconsistency associated with environmental effects. For breeders and biologists to address such matters at such a fundamental level, the factors that govern starch variability first need to be identified.

2000-01632 Optimization of Aeration Systems for Value-Added Crop Preservation

Montross, M.D.; McNeill, S.G.
University of Kentucky; Department of Biosystems and Agricultural Engineering; Lexington, KY 40546-0276
New Investigator, Strengthening Award; Grant 2001-35503-10025; $200,000; 3 years

Temperature management during grain storage is one of the most critical variables that affect the rate of deterioration. By maintaining proper temperatures during storage the development of insects can be minimized without the use of residual pesticides or fumigation. The overall goal of this research is to develop alternative aeration systems and strategies that will control grain temperatures during spring and summer storage more effectively. This will reduce the cost and improve the effectiveness of ambient and chilled aeration as non-chemical pest control techniques in stored food grain. Heat and mass transfer due to natural convection during periods of non-aerated storage can be very significant. Natural convection currents are primarily a function of the permeability of the grain mass. Before aeration systems or strategies are modified the effect of permeability on the natural convection currents and moisture migration needs to be further documented. An existing finite element model of the heat, mass, and momentum transfer during periods of non-aerated and aerated storage will be modified to take into account the effect of non-uniform airflow. The feasibility and application of partial ambient or chilled aeration can then be fully investigated. Verification of the aeration model will be done in pilot-scale flat bottom bins. Further verification of the non-uniform airflow heat and mass transfer model will be done using temperature data collected at commercial facilities. The results from this study will be important in evaluating and promoting aeration as an alternative non-chemical pest control strategy.

2000-01687 High Rosmarinic Acid Spearmint Clonal Lines for Nutraceutical and Food Preservative Applications

Shetty, K.

University of Massachusetts, Amherst; Department of Food Science; Amherst, MA 01003
Grant 2001-35503-10128; $193,300; 3 Years

The long-term goal of this project is to use the tools of biotechnology to develop improved and value-added varieties of food-grade dietary herbs to generate consistent, non-toxic and clinically relevant levels of phenolic metabolites for use as antioxidants and as antimicrobials against chronic diseases caused by ulcer-associated *Helicobacter pylori* and urinary tract infection-associated *Escherichia coli*. The major limitation of using dietary herbs for nutraceutical, medicine and food preservation applications is the inconsistency of phenolic phytochemicals due to the heterogeneity resulting from the cross-pollinating nature of their breeding characteristics and especially species in the family *Lamiaceae* or the mint family. In order to overcome the problem of phytochemical inconsistency due to genetic heterogeneity, patented plant tissue culture techniques have been developed to isolate a clonal pool of plants originating from a single seed. In this proposal this non-transgenic tissue culture-based approach coupled with a non-transgenic chromosome doubling strategy using Colchicine will be used to select several elite clonal lines of spearmint *(Menthaspicata).* These elite clonal lines (each clonal line originating from a different seed), following large scale clonal propagation (micropropagation) and evaluation of functionality, will be targeted as dietary sources of phenolics for antioxidant function and to control chronic bacterial diseases mentioned above. Superior diploid and tetraploid clonal lines will be genetically fingerprinted using Polymerase Chain Reaction. This project has significance for US Agriculture due to the development of elite value-added crop varieties like spearmint with applications as diet-based nutraceuticals and food preservatives.

2000-01796 Distribution of Lipid-soluble Antioxidants in Muscle Lipids and Effect on Stability

Hultin, H. O.; Decker, E. A.
University of Massachusetts, Amherst; Department of Food Science; Marine Station, Gloucester, MA 01930
Grant 2001-35503-10038; $151,100; 3 Years

Many minced muscle foods undergo quality loss due to the development of rancid flavors brought on by lipid oxidation. The lipids in muscle can be categorized as the triacylglycerols, i.e., fats and oils, or the polar lipids found in the membranes**.** The polar phospholipids of the membrane are more susceptible to oxidation than are the neutral tricylglycerols. Antioxidants may be added to foods to limit the rate and extent of rancidity due to lipid oxidation. Since the two classes of lipids are very different, it is likely that they will respond differently to antioxidation systems. The overall goal of this research is to improve the stability of minced muscle foods to lipid oxidation and/or to reduce the amount of lipid-soluble phenolic antioxidants that must be added to achieve a desired level of stability. In previous work we have shown that once an antioxidant is incorporated into one of the lipid classes, it does not distribute readily into the other class and that the dielectric constant (polarity or hydrophilicity) of the antioxidant carrier can markedly affect the uptake of the antioxidant into either the polar membrane lipids or the neutral fats and oils, We shall study the ways in which the antioxidants can be preferentially distributed into the specific lipid fractions and determine if this leads to

improved stability to lipid oxidation, Successful accomplishment of this research would lead to higher quality minced muscle foods for the consumer and longer shelf-life for the product.

2000-01144 Gas Chromatograph with Atomic Emission and Mass Spectrometer Detectors for Food and Water Analysis

Bushway, R .J.; Perkins, L. B.
University of Maine; Department of Food Science and Human Nutrition; Orono, ME 04469-5736 Equipment Grant; Grant 2001-35501-10190; $49,938; 1 Year

Food Safety has become an important issue in recent years and has resulted in the passage of the Food Quality Protection Act of 1996. The levels of pesticides contained in our food and water supplies are of great concern to the general public. Study of the types, concentrations and fate of the pesticides, which much of the population inadvertently consumes, provides regulatory agencies and growers, alike with information that can minimize risk to the environment and the public. This proposal requests funds to purchase a gas chromatograph equipped with mass spectrometer and atomic emission detectors. The investigators will use this equipment to support on-going method development in the area of pesticide research in food and water matrices. The apparatus will also be used to support other research projects in the Department of Food Science and Human Nutrition, as well as throughout the College of Natural Sciences, Forestry and Agriculture. These projects include assisting of faculty members in identifying volatile antioxidants in food, feed and biological tissue; support for the development of an organophosphate insecticide sensor, and the detection of chlorinated pesticides in lobster and other marine animals. In addition, the equipment will be used to support graduate, undergraduate and high school student research projects, as well as for public service events. This grant will aid the Food Science and Human Nutrition Department in securing additional funding from public and private sources.

2000-01923 Light Frequency Analysis, Fluorescence and Neural Networks for Fruit and Vegetable Quality Evaluation

Guyer, D. E; Brook, R.
Michigan State University; Department of Agricultural Engineering; E. Lansing, MI 48824
Grant 2001-35503-10026; $129,000; 2 Years

The scope of this research is to automatically and nondestructively differentiate the extent of desirable tissue from undesirable tissue on individual fruit and vegetables in the inspection of raw product streams. Automated electronic sorting technology has the potential to rapidly, consistently and accurately sort fruit and vegetables while additionally having the added feature of potentially identifying commodity characteristics which are not detectable by human sorters. Characteristics may be difficult to detect because they are internal to the fruit or the defect is very similar in color to the skin surface of the commodity and may be more accurately and efficiently detected in a region of the electromagnetic spectrum that is invisible to the human eye. The objective of this project is to determine if imaging of light energy reflectance in the visible and the extended near infrared regions, as well as imaging of chlorophyll fluorescence, can be successfully coupled with artificial neural network image analysis and be used to detect

and quantify common and grade reducing defects without incorrectly classifying stem and calyx zones.

A successful sorting system should improve the quality of the fruit packout, should reduce packing costs, and should improve returns to the grower who is faced with increasing quality and consistency demands by the consumer and increased international market competition. Sorting technology for raw product streams benefits the fruit and vegetable industry from the producers to the consumers by providing the potential to direct commodities to optimal markets and processes resulting in enhanced profits and final product quality.

2000-01688 Measuring the Long Term Acceptability of Foods: Effects of Sweetness

Vickers, Z.
University of Minnesota; Department of Food Science and Nutrition; St. Paul, MN 55108
Grant 2001-35503-10023; $125,904; 3 Years

A food with long-term acceptability is a food that can be repeatedly (daily, weekly) eaten even though other acceptable foods are available and the consumer has the necessary resources to obtain them. Our long-term goal is to determine the features of foods necessary for them to have long-term acceptability. The primary goal of this proposal is to test the hypothesis that overly sweet foods scoring highly in a taste test will decrease more in liking, consumption or choice when repeatedly eaten as compared to less sweet versions. This hypothesis has been developed on the basis of strong preliminary data suggesting that preferred levels of sweetness in taste tests do not predict the preferred levels of sweetness in either single consumption tests or repeated consumption tests. Our other goals are to compare methodologies for determining long-term acceptability and to determine whether measurements of sensory specific satiety can be used as a rapid method for predicting long-term acceptability. The rationale for the research is that once we understand the attributes that increase or diminish long-term acceptability, we will be able to design foods that have it. The very high rate of product failures in today's market shows the inadequacy of current methods of measuring food acceptability. The outcomes of this research will have significance because they will aid in developing test methods for measuring the long-term acceptability of foods and because they will increase our knowledge of sensory attributes important for repeated eating.

2000-01629 Flavor Formulation of Lower Fat Ice Cream by Instrumental and Sensory Approaches

Gruen, I. U.; Heymann, H.
University of Missouri, Columbia; Department of Food Science; Columbia, MO 65211
Grant 2001-35503-10176; $108,000; 2 Years

Fat reduction greatly influences the flavor of many foods, including ice creams, due to changes in interactions of the individual flavor components with other food ingredients. In the past, flavor-food interactions have been studied almost exclusively using simple model systems. This study is aimed at providing relevant and practical information for reformulating flavorings for lower fat foods. Ice creams with various fat levels will be flavored with a strawberry flavoring of known composition. Flavor profiles of these ice creams will be determined using descriptive sensory and instrumental

analysis. Based on the differences observed in these profiles, the strawberry flavoring will be reformulated for each fat level, so that the lower fat ice creams have the same instrumental flavor profile as the full fat ice cream. Sensory analysis will be used to determine if the flavor of the lower fat ice creams is identical to that of full fat ice cream as perceived by human senses. Odor and flavor thresholds as well as vapor-liquid partition coefficients of the chemical components of the flavoring will be determined to provide some fundamental information that will help explain the reformulation requirements. Flavoring lower fat food products so that they taste like full-fat products is still a considerable challenge for the food industry. Currently, highly trained flavorists reformulate flavorings using only their senses of taste and smell. A more objective and systematic approach to reformulating flavors using instrumental analysis in combination with sensory analysis may be an alternative avenue to accomplish this task.

2000-01982 5th International Hydrocolloids Conference

Foegeding, E. A.
North Carolina State University; Department of Food Science; Raleigh, NC 27695
Conference Award; Grant 00-35503-9555; $10,000; 1 Year

This is the 5th in a series of international conferences focused on how proteins and polysaccharides function in foods and related applications. In recent years, there has been a major focus on applying knowledge derived from plastics, textiles and other manufactured products to food systems. For example, knowledge developed in the plastics industry has been used in understanding what regulates the quality of baked goods, processed meats and dairy products. The long-term goal is to develop a series of scientific principles which can be used to describe texture, appearance and stability of foods. This would allow scientists in food research and product development to approach problems from a more fundamental basis and lower the reliance on empirical methods. The goal of this conference is to bring together an eclectic mix of industrial and academic scientists who are working with proteins and polysaccharides and utilizing polymer and materials models. The topics discussed in this conference have direct application to the following areas of the Food Characterization/Process/Product Research program: (a) fundamental studies of the structure-function relationships of food compounds related to performance in processes and products, (b) food quality quantification and (c) physical, chemical and biological modification of food components. The conference will be held on September 10 to 15, 2000. The venue will be the North Raleigh Hilton in Raleigh, NC. The venue will allow for all participants to stay in one hotel so those interactions are maximized.

2000-10203 Acquisition of a Food Nitrogen- Protein Determinator

Hadley, M.
North Dakota State University; Department of Food and Nutrition; Fargo, ND 58105
Equipment Grant; Grant 2001-35501-09907; $25,855; 1 Year

Funds will be used to purchase an FP-2000 Nitrogen Determinator system (FP). The FP has the capability of assessing the nitrogen concentration from 0.01% to 100% of a sample. Varietal difference in concentration and distribution of various components in a commodity are important to determine e.g., fiber. Fiber isolated from plant material contains protein. Thus, protein must be determined and subtracted from the fiber to

determine fiber concentration. Green leafy plants contain a protein known as Fraction-1-protein (F-1-p) that has good functional properties in food systems. For example, the foam produced by F-l-p on whipping compares favorably to the foam produced by egg whites and could be used to replace egg white in foams (e.g., meringues). F-1-p is nutritionally similar to eggs and could be consumed by vegetarians as a complete protein. In an attempt to find a suitable value-added source of F-l-p, the concentration of F-l-p will be determined in the leaves of various commodities e.g., rhubarb, potato, etc., and fractions at stages during its isolation and purification. Protein concentration in stored leaves will be compared to the freshly cut leaves to determine protein loss with storage. Other faculty will use the equipment in investigation into the role of *in vivo* lipid peroxidation in disease and the ability of antioxidant to reduce peroxidation using animal models. Semi-purified animal diets are fed to the animals, and it is essential that nutrients including protein be quantified in these diets before they are fed.

2000-01601 Relationship of Environment on Spring Wheat Glutenin Protein and Breadmaking Quality.

Khan, K.
North Dakota State University; Department of Cereal Science; Fargo, ND 58105
Strengthening Award; Grant 2001-35503-10032; $140,000; 2 Years

Wheat proteins, especially the glutenin proteins, have been shown to be the major fraction responsible for breadmaking quality differences among hard red spring (HRS) wheats. The same HRS wheat variety grown in different environments show differences in quality such as mixing and loaf volume. Since protein is mainly responsible for quality differences, we postulate that the different environments change the composition of the glutenin proteins in a wheat variety to cause these quality differences. In this project we are studying, through gel electrophoresis and other biochemical techniques, the protein compositional changes that occur in different environments of selected HRS wheat varieties to identify differences in protein composition that would explain the variation in the breadmaking quality factors such as mixing and loaf volume of these varieties. This type of information would be useful in a HRS spring wheat variety development program to plan future research on environmental factors such as temperature, rainfall, humidity, throughout the growing season to see how these factors cause changes in protein composition which in turn influence breadmaking quality. From this type of research we may be able to identify HRS wheat varieties that are better suited for certain environments over other environments for best breadmaking quality and marketability.

2000-01645 Validity and Predictability of Twin-Screw Food Extruder Modeling

Jaluria, Y.
Rutgers University; Department of Mechanical Engineering; Piscataway, NJ 08854.
Grant 2001-35503-10101; $131,500; 3 Years

Enhancing the value and use of agricultural products through processing and manufacturing is a very important segment of U.S. agriculture. Extrusion is a widely used method for the processing of a very wide range of food materials, such as those employed in cereals, snacks, pet foods, etc. A strong fundamental, quantitative and practical knowledge base is needed for improving the operation and optimization of the extruder in order to control, predict and enhance product quality and for lowering costs. This

information could also lead indirectly to innovative processing methods for existing products and to the development of new products. Mathematical and computational models are needed to provide much of these inputs because experimentation is both expensive and time-consuming. However, the models will be useful only if their validity, accuracy and predictability are satisfactorily established. This is the main objective of the proposed study. The focus is on twin-screw extruders because of their importance in the food industry and the lack of accurate simulation of the process considering many important issues involved in practical extruders. Such validated models can then be used to design and optimize the process, as well as to set appropriate operating conditions to achieve desired product characteristics. Therefore, the study is expected to lead to a better basic understanding of the extrusion process and to confidence in the modeling and simulation approach. This would allow modeling to be used for design, control, and optimization of the extruder, impacting on existing and new extrusion processes for a variety of food materials as well as on new extruded products.

2000-01786 Numerical Simulation and Validation of the Mixing of Viscoelastic Materials in Dough Mixers

Kokini, J.
Rutgers University; Department of Food Science; New Brunswick, NJ 08901-8520
Grant 2001-35503-10127; $180,000; 3 Years

Mixing is one of the most commonly used and important unit operations in the food industry, yet is not well understood. In particular, understanding flow and mixing patterns in dough mixing is a challenge. This is especially true when attempting to change from a batch to a continuous operation because of the extremely different flow and mixing patterns encountered. In fact, the transition from batch processing to continuous processing has been particularly slow in industry because matching mixing efficiency and dough quality of batch mixers in continuous mixers has proven to be non-trivial. Therefore, the main objective of this project is to gain better understanding of the mixing flows in both batch and continuous dough mixers.

The first phase of this project involves simulating the flow and mixing in both a batch and continuous dough mixer for several increasingly more complex model fluids including corn syrup, CMC, carbopol and wheat flour dough using FEM (finite element method). Then the accuracy of the simulation results will be verified experimentally using Laser Doppler Anemometry with the transparent fluids in mixers with Plexiglas walls to actually measure the mixing flows. These experiments will serve as a bridge to the long term objective of predicting the geometry and operating conditions that produce an equivalent dough mixing profile in a continuous mixer to that produced by a batch mixer. Success in this final objective will facilitate the design of continuous mixers that can be successfully used in industry during continuous processing of dough based foods.

2000-01594 Microwave-Convective Hot Air Drying of Vegetable Particulates

Roberts, J. S.
Cornell University; Food Science and Technology Department; Geneva, NY 14456
New Investigator Award; Grant 2001-35503-10036; $102,036; 2 Years

Drying extends the shelf life of perishable products and reduces the weight of products resulting in reduced transportation costs. Thus drying is one of the most

important processes in the food industry as well as one of the most frequently studied topics in food engineering. Dehydration involves the simultaneous input of heat and removal of moisture. Vegetables have a high moisture content necessitating high energy inputs to dry. Optimizing this process will result in lower cost and increased product quality. It is generally recognized that the internal moisture transfer is the rate-limiting mechanism during drying, however, there are discrepancies between predicted moisture profiles to experimental data. Moisture transfer is a temperature dependent process. To properly investigate the moisture transfer in a material, uniform temperature throughout the material is required during drying. In the past, this uniform temperature condition has not been achieved when studying moisture transfer and is thus the likely source of error when predicting moisture profiles. A large microwave oven was designed to supply continuous variable power along with a temperature control system to maintain the sample at a desired drying temperature below boiling. A controllable forced hot air system was added to the microwave unit to have the surface temperature equal to the internal sample temperature. A balance was incorporated with this drying apparatus so that drying curves can be obtained under constant
temperature conditions. Therefore, this equipment is ideal for investigating the moisture transfer mechanism(s) that limit the drying process for vegetables.

2000-01803 Odor and Aroma Release from Foods

Acree, T. E.; Halpern, B. P.
Cornell University; Food Science and Technology; Geneva, NY 14456
Grant 2001-35503-10102; $144,500; 2 Years

A retronasal aroma simulator (RAS), developed previously with NRI support, will be used to investigate the release of aroma chemicals from food systems. The RAS accounts for conditions in the mouth that affect aroma chemical release caused by changes in pH, dilution with saliva, maceration caused by chewing and oral manipulation as well as thermal effect caused by body heat when food is exposed to the mouth environment. This project extends these developments by applying the RAS to investigate effects on aroma chemical release from homogeneous and heterogeneous foods while evaluating the time release parameter. By comparing dynamic aroma chemical release from a homogeneous food to a multi-phase heterogeneous food, the impact of dynamic aroma chemical release on the flavor of a wide range of foods can be anticipated. Comparing these results with standardized sensory descriptive data can demonstrate the role aroma chemical release plays in perception and allows for the construction of mathematical models that help predict flavor. Understanding how ingredients interact with physical conditions to modulate the release of aroma chemicals from solid and liquid foods can be used to predict the impact of crop genetics, storage, distribution, and reformulation on both natural and engineered foods. Results from this research will simplify the manufacture of both natural and engineered foods that have enhanced quality and greater consumer acceptance. Industry will also have a protocol to measure aroma chemical release from a wide range of foods.

2000-01798 Moderate Electric Field Processing: A Theoretical and Experimental Investigation

Sastry, S. K.

The Ohio State University Research Foundation; Columbus, OH 43210.
Grant 2001-35503-10035; $186,000, 3 Years

Recently accumulated evidence indicates that moderate electric fields have significant and possibly economically far-reaching effects on the processing of cellular food materials. Some promising applications are in speeding up drying processes by a brief electrical treatment, acceleration of fermentation by moderate electric fields, reduction of water use during industrial blanching, and improvement of extraction. These processes will be of great importance in the coming years as the biotechnology industry develops new fermentation methods, and as extraction of valuable anticancer agents are pursued by the pharmaceutical and food industry. If this research is successful, industry will not only benefit from increased productivity by the use of Moderate Electric Fields (MEF), but could do so with energy savings and reduced environmental costs. However, a fundamental investigation is necessary to more fully exploit these effects.

We propose a three-pronged investigation to aid the understanding of permeabilization and provide insights into new processes. Our objectives are:
(1) To develop models for electric field and charge distributions in cellular materials exposed to arbitrary waveform electric fields, and to combine this information with the existing knowledge base in biophysics to predict the permeabilizing effect of a particular treatment.
(2) To qualitatively verify the models developed under objective 1. We propose to subject cells to controlled pressure, temperature, electric field waveform and frequency; and study impedance changes on nanosecond time scales, to identify situations of reversible pore formation.
(3) To use the above findings in identifying and testing a limited number of promising avenues for MEF processing.

2000-01191 Development of Non-Destructive Methods of Analysis by SW-NIR

Cavinato, A.G.
Eastern Oregon University; Department of Chemistry; La Grande, OR 97850
Equipment Grant; Grant 2001-35501-10160; $16,019; 1 Year

Food safety is of critical importance for a myriad of smoked and cured fish products on our markets. These foods do not receive a heat treatment, which would kill harmful microorganisms and often pose food safety risks if not properly processed or handled. Several parameters are closely monitored including water and salt content to ensure that these foods do not support the growth of dangerous microorganisms. Only destructive and lengthy methods are currently available for such measurements. The purpose of this project is to develop rapid methods of analysis that can measure the amount of water and salt in a variety of seafood products such as salmon caviar (ikura), smoked salmon of different types, and cured salmon (teijin) without destroying the sample. The methods will be based on a fiber optic spectrometer, which measures the amount of near infrared light absorbed by the sample. Specific objectives for this project include determining how fish tissue and roe interact with near infrared light; ensuring that measurements are representative of the bulk properties of these foods; tailoring the design of the optic probes for the specific types of samples; developing methods of analysis for water and salt that can be used in the seafood industry. The availability of fast and

non-destructive tests will assist processors in developing safe and consistently high quality products.

2000-01638 Cell Surface Physiology and Phage Infection of Cheese Starter Bacteria

Geller, B.L.
Oregon State University, Corvallis; Department of Microbiology; Corvallis, Oregon 97331-3804

Grant 2001-35503-10034; $186,00, 3 Years

This project will investigate specific molecular events that initiate virus (phage) infection of the bacterium *Lactococcus lactis*. The long-term goal is to create virus-resistant strains of *L. lactis*. *L. lactis* is essential for making American type cheeses (mostly cheddar), which are value-added products with a yearly wholesale U.S. market value of over $5.6 billion. The most persistent and costly problem in cheese factories is viral infections of *L. lactis,* which kill the bacteria and ruin the cheese. Viruses that attack and kill *L. lactis* are natural contaminants of milk and cheese factory equipment. Traditional methods of isolating virus-resistant strains by natural selection have not solved the problem.

I have developed a strategy of genetically engineering *L. lactis* that disallows virus infection. The strategy involves deleting one gene from the bacterium. Without this gene, viruses do not recognize *L. lactis* as a host because the engineered bacterium lacks an attachment site on its surface required for virus infection. We named the attachment site and the gene "pip".

Strains that lack pip are completely resistant to one (c2) of three main groups of viruses that cause problems in cheese factories. Moreover, a c2 virus has never been found that can infect a strain that lacks pip, despite repeated attempts to detect such a mutant c2 virus. This suggests that it is difficult for c2 virus to overcome the pip deletion strategy. Fortunately, deleting the pip gene causes no change in the growth or metabolic characteristics of *L .lactis*. Therefore, the strategy of deleting pip to make virus-resistant strains is a practical solution to part of the problem.

The discovery of pip and its subsequent application were an outcome of research aimed at understanding the molecular mechanism of virus infection. Currently, the way that viruses use pip to attach to and inject their genes into *L. lactis* is the best-understood model of the early steps of virus infection in this type of bacterium. We plan to extend our understanding of the virus infection cycle so that we may rationally design additional applications for overcoming the virus problem in cheese factories.

The specific objectives of this proposal are: (1) Determine the subcellular location of pip on the surface of *L. lactis*, and (2) Identify the molecular region of pip that anchors it to the cell surface.

Objective 1 will be met by breaking open cells of *L. lactis* and dividing the broken cells into subcellular parts using physical and chemical techniques. Each subcellular fraction will be analyzed for pip, using molecular techniques with high specificity and sensitivity. The subcellular location of pip is important because its proposed role in virus infection requires that it act at the cellular membrane. Yet there is ambiguous and possibly conflicting data suggesting that pip may be located either in the cellular membrane or more distally in the cell wall.

To address the second objective, specific mutations will be made that encode signals for anchoring pip to the bacterial cell surface. One of these signals is thought to anchor pip to the cellular membrane. The other is a putative cell wall anchoring signal. Mutating one of these regions should have no effect on the subcellular location of pip, whereas mutating the other should misdirect pip to an abnormal location. The results of this objective will help define the subcellular location of pip and the mechanism of virus infection.

2000-01652 Innovative Far-Near Infrared Process for Selective Heating of Food Components

Irudayaraj, J; Puri, V. M.
The Pennsylvania State University, University Park; Department of Agricultural and Biological Engineering; University Park, PA 16802
Grant 2001-35503-10103; $121,500; 2 Years

A novel Far-infrared (FIR) technology utilizing the intrinsic absorption characteristics of proteins, fats, and carbohydrates to selectively heat specific food components of choice is proposed. FIR's excellent control and surface heating characteristic will render it compatible with near infrared and microwave heating for combination heating. Before this technology reaches maturation, much remains to be learned on the effect of FIR radiation on food microstructure and chemical structure, pasteurization, and taste and flavor compounds. Selective heating of specific food components (protein, fat, carbohydrate) will help develop products with desired or prescribed quality attributes with a wide range of applications in food coatings, rapid surface heating to seal moisture and retain juiciness in food. This technology could open the doors for economical and rapid in-package pasteurization/sterilization of foods.

Paving the pathway toward the development of this innovative technology, the specific objectives are to (1) evaluate the feasibility of selective heating using FIR radiation, (2) increase the understanding of FIR radiation penetration and its absorbance by food components, (3) explain specific changes in the chemical and physical structure of FIR processed foods. A packaged (meat) and an unpackaged (potato) system will be chosen. Chemical structure information from Fourier-transform infrared photoacoustic spectroscopy and physical and chemical structure information from Atomic Force Microscopy will help to understand the effect of IR radiation and penetration on individual components. Specific wavelength windows that effectively heat the food components will be discussed and the engineering basis for equipment design will be studied.

2000-01740 Surface Hydrophobicity and Functionality of Proteins in the Molten Globule State

Powers, J. R.; Dunker, A. K.; Swanson, B.G.
Washington State University, Pullman; Department of Food Science and Human Nutrition; Pullman, WA 99164-6376
Grant 2001-35503-10031; $187,800; 3 Years

The molten globule is an intermediate structural state of protein between the native ordered state and fully unfolded denatured state. Proteins in the molten globule state possess unique molecular structures with enhanced surface and core hydrophobicity. The

hydrophobic structure of the molten globule state may improve functional properties of proteins such as flavor binding, foaming, emulsification, and gelation compared to the native protein. (-lactoglobulin, a major protein in whey, has been selected for experimentation to enhance its functionality as a food ingredient as well as to promote the utilization of whey proteins.

The molten globule of (-lactoglobulin induced by high hydrostatic pressure (HHP) exhibits approximately three times greater hydrophobicity than that of the native protein due to the rearrangement of the secondary structure and conformational changes of the tertiary structure. The molten globule state of (-lactoglobulin is structurally stabilized by covalent disulfide bonds.

We hypothesize that the stable molten globule of (-lactoglobulin will exhibit more binding sites and less binding affinity for hydrophobic flavor compounds than the native (-lactoglobulin and will carry flavors for formulated reduced fat food products and release flavors during consumption.

2000-01617 Non-Invasive Method for Predicting Safety and Quality of Foods

Rasco, B.A.; Cavinato, A.G.; Bledsoe, G.E.
Washington State University; Department of Food Science and Human Nutrition; Pullman, WA 99164-6376
Grant 2001-35503-10033; $200,000.00 for 3 Years

Food safety is critically important to the myriad of highly perishable smoked and cured foods produced in the United States. Market demand is for lower salt products, increasing the food safety risk compared to more traditional forms of the same food. Smoked and cured seafood products is a multi-billion dollar industry in the United States. These products, particularly fish roe foods, are destined for export markets. International demand is growing for US cured and smoked aquatic foods, from both the wild fishery and aquaculture. These products command high prices: salmon caviar up to $5.00/oz, and black caviar, tens of dollars per ounce. Customer are placing stringent demands on the microbiological safety of these foods. Better ways of assuring good process control during manufacture are needed. Salt is added for the unique flavor and texture characteristic of caviars and smoked fish, and also to control harmful bacteria. However, a less than optimal number of food safety tests are conducted during or after production because of the high cost of lost product from sampling and the long time required for currently available tests. A rapid test, particularly for salt, which would not require product destruction during testing would be an important development. In this project, we develop a method using a special type of infrared spectrometer. This instrument can measure both the water content and salt content in intact food items. In this project, we will test: pollock, herring and sturgeon caviar, cured salmon (lox type products) and smoked salmon.

2000-01608 Enzymatic Modification of Native Fats and Oils to Produce Value-Added Products

Hill, C. G., Jr.
University of Wisconsin, Madison; Department of Chemical Engineering; Madison, WI 53706
Grant 2001-35503-09912; $131,500; 2 Years

Innumerable epidemiological surveys and studies of animal models indicate that dietary ingestion of particular fats is associated with both coronary heart disease and various forms of cancer. Because these pathophysiological conditions in humans have been linked to dietary factors, many manufacturers are interested in the production of foods designed for consumption by individuals who are high-risk candidates for these diseases. The proposed research will generate the experimental data and process models necessary to conduct preliminary assessments of the technical and economic feasibility of employing enzyme-mediated reactions to produce modified oils and fats. These modifications will increase the value of the original fat or oil by replacing those saturated fatty acid residues that are responsible for adverse physiological effects with residues that are either benign or confer preventative or therapeutic health benefits (e.g., unsaturated fatty acids such as conjugated linoleic acid or omega-3 fatty acids). The unique high value food products that result can be marketed as nutraceuticals intended for ingestion by individuals who suffer dietary restrictions for medical reasons or who are particularly health conscious. Use of immobilized lipases to catalyze the acidolysis reactions of omega-3 fatty acids and conjugated linoleic acid with the triacylglycerols which constitute native oils and fats is a technology by which one can modify the composition of the native materials to obtain value-added products with potential therapeutic and preventative medicinal benefits. The experimental work will involve identification of food grade enzymes that have appropriate (high) specificities for release of the saturated fatty acid residues and characterization of the rates at which these residues are released from the three positions in the triglyceride molecules which constitute the native fats and oils.